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Preliminary Analysis of the Projected Life of Gypsum/Polyethylene Railroad Ties

By
Dr. Richard D. Sudduth

Manufacturing Extension Partnership of Louisiana and the
Chemical Engineering Department
University of Louisiana at Lafayette

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Introduction

Recently a new patent to make railroad ties from gypsum/polyethylene compounds has been issued to John Bayer[1], the Managing Member of PolySum Technologies, LLC. Railroad ties have traditionally been made of wood impregnated with Creosote. However, Nosker and Renfree[2] point out that various factors limit the usefulness of wooden crossties. The activity of biological organisms, particularly in moist, humid surroundings, shortens the service life of wooden ties. Wood crossties are pressure-treated with an EPA –registered pesticide containing creosote to provide protection from insect attack and decay. In addition, although the EPA does not classify the treated crossties as hazardous waste, the creosote itself is identified as a potentially cancer-causing chemical and there are increasingly strict environmental guidelines for creosote treatment facilities.

Despite this treatment, the life span of wood cross ties still falls significantly short (to ten years in some cases) under the following 'severe service' areas: High Tonnage areas, curves, switches, bridges, under-grade crossings, paved areas, humid environments, areas susceptible to bug infestation. It is suspected that the major problem in this instance is that wood has a low compression strength. Initial compounding and testing results[3-6] comparing the compression strength of oak wood and the new polyethylene/gypsum composites are shown in Figure 1.

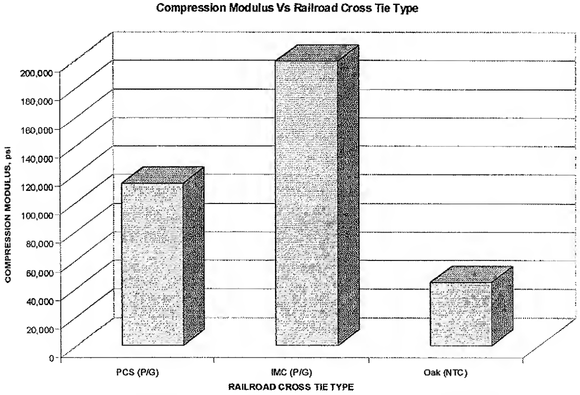

Figure 1 Compression Modulus of Oak Wood Compared to Polyethylene Compounded Gypsum from PCS and IMC- Agrico

Note in Figure 1 that the new gypsum compounds have significantly higher compression strength than the Oak Wood products. As a result, it is felt that the new gypsum products will be more effective than wood in the 'severe service' locations. Also since polyethylene itself is normally insensitive to water, the new polyethylene compounded materials would not be expected to rot like wood products do and they can be recycled.

Other patents have also been issued[7-11] on several other combinations of materials for use as railroad ties. The one with the highest compression strength is the concrete ties[7]. However, the concrete ties are nearly three times more costly than the wooden ties and they have almost no elongation to break in a flexural mode.

Plastic Lumber Projected Life Warranties

Several plastic lumber products that are currently on the market are summarized in Table 1. All of these plastic lumber products have been made at least partially from polyethylene. Note that each is also warranted for a specific time frame. In general these warranties appear to indicate that these plastic lumber products will not rot, crack, split or be damaged by termites. However, after having made appropriate inquiries, no substantiating data has been indicated from any of these companies justifying the warranted life times indicated.

Never-the-less, both Dr. Thomas Nosker and Dr. Richard Renfree[12] of Rutgers University were contacted to discuss their interpretation of the length of time plastic lumber can be expected to be effective. First, they described some unpublished data that will be presented at the ANTEC conference in 2001. Apparently they were recently able to evaluate the plastic lumber from a deck that had been exposed to the weather for 11 years. This deck was taken apart and the aged plastic lumber was evaluated for mechanical properties. The plastic lumber used in this instance was all plastic with no filler. This plastic lumber was made from approximately 80% polyethylene and the remainder included other plastics such as polystyrene. This deck had plastic lumber joists that were 2" X 6", decking that was 2" X 6", and posts that were 4" X 4". The surprising result was that they found that the flex strength of the aged material had a flex modulus that had increased approximately 25% over the virgin material that had been evaluated 11 years earlier. They hypothesized that the increase in flex strength resulted from the annealing of the polyethylene in the sun. However, this confirmation has not yet been established.

In addition, Dr. Renfree[12] indicated that plastic lumber exposed to the weather would be expected to have a projected loss of approximately 3 mils to the weather per year. However, Dr. Renfree was not able to provide the data justifying this prediction at this time. In an effort to evaluate this thickness, Dr. Renfree will be sending a sample of their 11 year old aged polyethylene plastic lumber to UL Lafayette to evaluation of the aged layer thickness.

A deterioration of polyethylene's mechanical properties when exposed to sunlight and oxygen for long periods of time was suggested to be possible by Kalb[13]. The exact amount of deterioration was not specified since it was known that the penetration of ultraviolet (UV) energy can be significantly reduced by only a small amount of mass. This limits the layer degraded by UV energy to only the surface layer. However, with the use of such additives as carbon black

and other potential UV absorbing or scattering additives (i.e. gypsum) this degraded surface layer can be substantially minimized.

Therefore the 3 mil degradation layer suggested by Renfree[12] is probably reasonable. If we assume that the growth of this degradation layer is reasonable, then the maximum degradation layer over a 50 year time span will be approximately 50 x 3mils = 150 mils = .150 inches. For a decking that is 2" thick this maximum degradation layer would be .15/2 = .075= 7.5% of the thickness of the cross section. However, for a railroad cross tie that is 7 inches thick this would only be approximately 2.5% of the overall thickness. This would suggest a maximum loss of approximately 2.5% in the flex strength. And we have already seen that the flex modulus had actually increased in the first 10 years so that the maximum loss would be something less than 2.5%. **This suggests that the crossties should be able to last at least 50 years.**

It has also been found that many of the gypsums that could be used to make railroad ties are mildly radioactive since they often contain a small amount of Radium 226. Initial measurements indicate that the radiation produced by from gypsum can be significantly reduced by encapsulation in polyethylene. Detailed measurements of the magnitude of this reduction will need to be determined for each formulation. Surprisingly, it is felt that the influence of the small amount of radiation from radium in this instance will have a positive influence on the physical properties of polyethylene in this formulation. Kalb[13] and others[14-15] have found that radiation doses through 10^8 rad increases crosslinking and generally improves the other physical properties of polyethylene. This again suggests that the mechanical properties of the gypsum filled polyethylene should be able to survive very satisfactorily to an age of at least 50 years. It is also possible that the gypsum filled polyethylene could potentially retain physical properties even better than the unmodified polyethylene after aging in the weather.

Recommendation

Based on the results identified above it appears to be reasonable to expect that the gypsum/polyethylene compounded railroad ties should last at least 50 years before they would need to be recycled to make additional products.

References

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Table 1

Projected Life of Selected Plastic Lumber Products

Vendor of Plastic Lumber	Product Designation	Designated Composition	Company Warranty, years	Reference
U.S. Plastic Lumber Ltd.	Smart Deck	Wood Filler and Polyethylene	10	Personal Communication
U.S. Plastic Lumber Ltd.	Carefree	100% polyethylene	50	Web Site and Personal Communication
U.S. Plastic Lumber Ltd.	Trimax	Fiberglass and Polyethylene	50	Web Site and Personal Communication
Trex Company	Trex Easy Care Decking	Wood Filler and Polyethylene	10	Web Site and Personal Communication